showing the horizontal axis of the spiral is half-way between the bottom and surface of the tank, in which the water is now simply revolving round this axis.

This is the vortex in its simplest and rarest form (for a vortex cannot exist with its ends exposed). Like an army it must have its flanks protected; hence a straight vortex can only exist where it has two surfaces to cover its flanks, and parallel vertical surfaces are not common in nature. The vortex can bend, and, with a horse shoe axis, can rest both its flanks on the same surface, as this piece of clay, or unite its ends with a ring axis, which is its commonest form, as in the smoke ring. In both these cases the vortex will be in motion through the fluid, and less easy to observe.

These vortices have no motion beyond the rotation because they are half-way down the tank. If the vane were shorter they would follow the vane; if it were longer they would leave it.

In the same way, if instead of one vortex there were two vortices, with their axis parallel, extending right across, the one above another, they would move together along the tank.

I replace the float by another which has a vane suspended from it, so that the water can pass both above and below the vane extending right across the middle portion of the tank. In this case I institute two colour bands, one to pass over the top, the other underneath the vane, which colour bands will render visible a section of each vortex just as in the last case. I now set the float in motion, and the two vortices turn towards each other in opposite directions. They are formed by the water moving over the surface of the vane, downwards to get under it, upwards to get over it, so that the rotation in the upper vortex is opposite to that in the lower. All this is just the same as before, but instead of these vortices standing still as before, they follow at a definite distance from the vane, which continues its motion along the tank without resistance.

Now this experiment shows, in the simplest form, the *modus operandi* by which internal waves can exist in fluid without any motion in the external boundary. Not only is this plate moving flatwise through the water, but it is followed by all the water, coloured and uncoloured, enclosed in these cylindrical vortices. Now, although there is no absolute surface visible, yet there is a definite surface which encloses these moving vortices, and separates them from the water which moves out of their way. This surface will be rendered visible in another experiment I shall show you. Thus, the water which has only wave motion is bounded by a definite surface, the motion of which corresponds to the wave; but inside this closed surface there is also water, so that we cannot see the surface, and this water inside is moving round and round, but so that its motion at the bounding surface is everywhere the same as that of the outside water.

The two masses of water do not mix. That outside moves out of the way of and past the vortices over the bounding surface, while the vortices move round and round inside the surface in such a way that it is moving in exactly the same manner at the surface as the wave surface outside.

This is the key to the internal motion of water. You cannot have a pure wave motion inside a mass of fluid with its boundaries at rest, but you have a compound motion, a wave motion outside, and a vortex within, which fulfils the condition that there shall be no sliding of the fluid over fluid at the boundary.

A means which I hope may make the essential conditions of this motion clearer occurred to me while preparing this lecture, and to this I will now ask your attention. I have here a number of layers of cotton-wool (wadding). Now I can force any body along between these layers of wadding. They yield, as by a wave, and let it go through; but the wadding must slide over the surface of the body so moving through it. And this it must *not* do if it illustrate the conditions of fluid motion. Now, there is one way, and only one way, in which material can be got through between the sheets of wadding without slipping. It must roll through; but this is not enough, because if it rolls on the under surface it will be slipping on the upper. But if we have two rollers, one on the top of the other, between the sheets, then the lower roller rolls on the bottom sheet, the upper roller rolls against the upper sheet, so that there is no slipping between the rollers or the wadding, and, equally important, there is no slipping between the rollers as they roll on each other. I have only to place a sheet of canvas between the rollers and draw it through; both the flannel rollers roll on the canvas and on the wadding, which they pass through without slipping, causing the wadding to move in a wave outside them, and affording a complete parable of the vortex motion.

I will now show by colour bands some of the more striking phenomena of internal motion, as presented by nature's favourite form of vortex, the vortex ring, which may be described as two horse-shoe vortices with their ends founded on each other.

To show the surface separating the water moving with the vortex from that which gives way outside, I discharge from this orifice a mass of coloured water, which has a vortex ring in it formed by the surface, as already described. You see the beautifully-defined mass moving on slowly through the fluid, with the proper vortex ring motion, but very slow. It will not go far before a change takes place, owing to the diffusion of the vortex motion across the bounding surface; then the coloured surface will be wound into the ring which will appear. The mass approaches the disc in front. It cannot pass, but will come up and carry the disc forward; but the disc, although it does not destroy the ring, disturbs the motion.

If I send a more energetic ring, it will explain the phenomenon I showed you at the beginning of this lecture; it carries the disc forward as if struck with a hammer. This blow is not simply the weight of the coloured ring, but of the whole moving mass and the wave outside. The ring cannot pass the disc without destruction with the attendant wave.

Not only can a ring follow a disc, but, as with the plane vane, so with the disc; if we start a disc, we must start a ring behind it.

I will now fulfil my promise to reveal the silent messenger I sent to those balloons. The messenger appears in the form of a large smoke ring, which is a vortex ring in air rendered visible by smoke instead of colour. The origination of these rings has been carefully set so that the balloons are beyond the surface which separates the moving mass of water from the wave, so that they are subject to the wave motion only. If they are within this surface they will disturb the direction of the ring, if they do not break it up.

These are, if I may say so, the phenomenal instances of internal motion of fluids. Phenomenal in their simplicity, they are of intense interest, like the pendulum, as furnishing the clue to the more complex. It is by the light we gather from their study that we can hope to interpret the parable of the vortex wrapped up in the wave, as applied to the wind of heaven, and the grand phenomenon of the clouds, as well as those things which directly concern us, such as the resistance of our ships.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Oxford.—The Curators of the University Chest have been authorised by Congregation to pay the following sums.

To the Delegates of the Museum, a sum of £140 for each of the years 1894, 1895, for the general expenses of the Museum.

To the Curators of the Botanic Garden a sum not exceeding £200, to provide for expenses incurred in connection with the erection of new houses in the garden.

The Curators of the University Chest have been authorised to expend a sum not exceeding £700 in making the rooms in the south corridor in the Museum, and the lofts over them, available for the use of the Hope Professor of Zoology, and to pay to the Hope Professor of Zoology, in addition to the statutable grant, the sum of £100 for each of the years 1894–1898, to provide for the salary of the attendant and other expenses of the Department.

The Delegates of Local Examinations have approved of the introduction of a new examination in the course for junior candidates in elementary physiology and hygiene.

Amongst those on whom it is proposed to confer the honorary degree of D.C.L. at the Encænia, is the name of Mr. Francis Galton, F.R.S.

One or more Natural Science Demyships, and Natural Science Exhibitions will be awarded by Magdalen College in October this year, the examination to commence on Tuesday, October 9.

At Wadham College, in the Scholarship examinations which will begin on Thursday, November 29, no papers in natural science will be set, but in the election to one of the Exhibitions preference will be given to any candidate who shall undertake to read for honours in natural science, and to proceed to a degree in medicine in the University of Oxford.

At Keble College an election will be held to one Scholarship

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in natural science of the value of £60 per annum, with laboratory fees not exceeding £20 per annum, on December 11 next. The examination will consist of papers in biology and chemistry, and all inquiries respecting the examination should be addressed to Mr. W. Hatchett Jackson, Keble College. The examination will begin on Thursday, December 6.

Mr. R. Warington, F.R.S., has been elected to the Sibthorpian Chair of Rural Economy, in succession to Sir John Gilbert.

CAMBRIDGE.—This year, for the first time on record, there is a bracket of two for the Senior Wranglership. In 1887 four names were bracketed for the highest place. These are the only instances in which the Senior Wrangler of the year has not stood "alone in his glory." Messrs. W. S. Adie and W. F. Sedgwick, both of Trinity College, share the honour. There is one lady wrangler, Miss E. H. Cooke, of Girton, who is bracketed twenty-eighth. In the second part of the Mathematical Tripos, a lady of Newnham, Miss A. M. J. E. Johnson, who was between fifth and sixth in the first part last year, heads the list, as she is placed alone in the first division of the first class. The Tyson Medal, for astronomy, offered this year for the first time, is not awarded.

Seven names appear in the first list of the Mechanical Sciences Tripo, all three of those in the first class having already taken the B.A. degree on some other examinination.

The Harkness Studentship in Geology has failed of award, in the absence of candidates.

The degree of Sc.D. is to be conferred on Professor Demetri Ivanovitch Mendeléef, of St. Petersburg, who was not able to accept the honour when it was offered him in 1889.

The following are appointed examiners for the new diploma in Agricultural Science: W. F. Darwin, Mr. W. G. P. Ellis, Professor Liveing, Mr. T. B. Wood, Professor Foster, Mr. A. Eichholz, Mr. A. E. Shipley, Mr. C. Warburton, Professor Hughes, Mr. P. Lake, Mr. O. P. Fisher, Mr. E. Clarke, and Mr. R. Menzies.

THE Scottish Association for the Promotion of Technical and Secondary Education have presented a memorial to Mr. Acland asking that the yearly examinations of the Department of Science and Art shall be held in the day as well as in the evening. It is pointed out that originally arranged, as they were, to suit the convenience of artisan pupils who could not be expected to attend during the day, these evening examinations are now taken by large and increasing numbers of pupils of secondary and higher grade schools. While, therefore, fully recognising the necessity which exists for examinations in all stages of art and science subjects being continued in the evening as heretofore, the memorialists urge the desirability of provision being made by the Department for the examination, within school hours, of pupils attending day schools.

SIR PHILIP MAGNUS has been appointed to represent the University of London at the bicentenary celebration of Halle University, to be held in August next.

SCIENTIFIC SERIALS.

Bulletin de l'Académie Royale de Belgique, No. 3.—Experimental demonstration of the purely accidental character of the critical state, by P. de Heen. A small quantity of amylene was introduced into the bottom of a tube, and surmounted by mercury, the tube being so thin that the mercury remained at the top. The tube was placed inside a box with glass windows, which was then heated to temperatures ranging from 201° C., the critical temperature of amylene, to about 350°. The tube was connected at the top with a Cailletet compression apparatus. It was found that even under pressures less than 5 atmospheres the amylene could be heated to 350° without evaporating. The critical state, characterised by turbulent movements, was never exhibited, but if by some accident a small quantity of vapour was formed the critical state set in at once. The author concludes that the critical state consists of a non-homogeneous mixture of "liquidogenic" and "gazogenic" molecules. At a certain high temperature, estimated for most liquids at 800° or 900°, the former are completely dissociated, and the pressure-volume curve becomes a simple isothermal. But the state of a fluid is not defined by pressure and temperature alone, since at the critical temperature, and at zero pressure, the volume can vary from unity to infinity.—Facts relating to the properties of carbon bisulphide, by H. Arctowski. The boiling point of pure carbon bisulphide is 46°·27, but this rises steadily during the process of determining it. The bisulphide is partially decomposed by the sun's rays, by moist air, and by a slight elevation of temperature continued for some time.—On the solubilities of the haloid salts of mercury in carbon bisulphide, by the same author. These salts show different solubilities, the iodide being the most, and the chloride the least soluble. The solubilities show a point of upward inflection at about 15° C. From 15° to –10° the lines of solubility converge in such a manner that if produced they would meet the axis of solubilities at a point corresponding to –25°.—Some experiments in experimental pathological embryology, by P. Francotte. Some ova of *Leptoplana tremellaris* were opened with a find steel point to admit schizomycetes. The microbes were either digested or excreted. The author concludes that microbian diseases cannot be transmitted by either ova or spermatozoa.

THE *Meteorologische Zeitschrift* for May contains a discussion of the results of meteorological observations on the Pic du Midi, by Dr. F. Klengel. The observations dealt with are those made during the years 1874-81 (excepting 1877), at the Plantade station, situated at a Pass, at an elevation of 7760 feet, and they furnish important materials respecting the climatic peculiarities of the high Pyrenees. The mean temperature was 34°·2; the absolute minimum was –11°·2 in Jauuary 1878, and the maximum 77°·4, in August 1881. Frost was observed on an average on 224 days in the year; the absolute maxima in all months were above 32°, and the minima mostly below 32°, even in July and August. The rainfall was exceedingly copious, amounting in the year to no less than 93·5 inches, a quantity which is only equalled at a few other places in Europe. The wettest month was April, with 18 inches, and the dryest July, with 2·7 inches. The distribution of rainfall throughout the year was extremely irregular; the number of wet days in the year amounted to 184. The most prevalent winds were from north-west, 25 per cent., and from south-west, 23 per cent. The French Meteorological Office has published in its *Annales* the observations made at the summit of the mountain since October 1881, at a still greater altitude; these will, no doubt, be dealt with in a subsequent paper.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 24.—"Measurements of the Absolute Specific Resistance of pure Electrolytic Copper." By J. W. Swan and J. Rhodin.

This paper is a record of measurements of the absolute specific resistance and temperature coefficient of pure electrolytic copper. The authors compared a large number of different specimens of electrolytic copper. Several of the specimens were at first roughly examined, and the best chosen for further investigation. The best of these was then electrolytically refined. This, without previous fusion, was drawn through sapphire dies to the requisite diameter, and the resulting wire subjected to careful measurements. The first specimen, "A," was measured both when hard and also after annealing at a red heat in an atmosphere of carbon dioxide gas; the second sample, "B," was only examined after annealing. The authors took extreme care in finding the dimensions of the wires and the temperatures at which they were measured.

The values of the two specimens in C.G.S. units were as follows, the density being 8·9587 at 15° C.

			Absolute specific resistance. C.G.S. units.	Temp. coefficient. Δt.
Sample	A.	Hard, as drawn......	1603	0·00408
,,	A.	Soft, as annealed....	1566	0·00418
,,	B.	Soft, as annealed....	1559	0·00415

May 31.—"On Rapid Changes of Atmospheric Temperature, especially during Föhn, and the Methods of observing them." By J. Y. Buchanan, F.R.S.

In July 1893, on the west coast of Scotland, föhn of a well-defined type prevailed. It was characterised by puffs of very hot air occurring every two or three minutes in the midst of the abnormally warm air of the day. On July 7 and 8 these hot

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